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ABSTRACT

This report discusses how a computer was used to enhance the curriculum of a college calculus course. Problems with a calculus adjunct course in computer science are detailed, along with the nature of changes in the new program. The changes moved from student use of the computer as an automatic typewriter to use as a tool with instructional programs. Examples of ten assignments directed toward computer use are presented. The view expressed is that the results of the course changes exceeded expectations, with assignments so heavily intertwined with calculus topics that the students were gaining insights into mathematics through the activities. (MP)

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COMPUTER SUPPLEMENTS FOR CALCULUS I

A discussion of how the computer was used to enhance the curriculum in Calculus I. All assignments were extra credit and no programming was required. Students became enthusiastic computer users while gaining insights into Calculus topics.

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COMPUTER CALCULUS ADJUNCT
HISTORY AT W.C.C.

The Washtenaw Community College math dept. has long felt that all Calculus I students should be exposed to computer activities. We tried offering a mandatory co-requisite one credit hour computer adjunct course. We hoped that in a separate course the burden of computerizing Calculus would be taken from a potentially non-computerized math teacher. This course was not a success for a number of reasons.

1. We didn't force students who weren't co-enrolled in the adjunct to drop Calculus I.
2. Calculus was already 5 credit hours, 6 was too much.
3. The teachers of the computer course were **too computer oriented** to interface the calculus topics into what became a programming class.
4. It is very difficult to create a new course in the middle of the traditional Math—Science—Engineering two year curriculum for transfer students.

The responsibility of exposing the Calculus students to computers reverted to the math teacher.

The adjunct course was dropped and my first efforts to replace the adjunct course with special computer assignments were rather limited. I stored practice tests in the computer and students had to sign-on to a computer terminal in order to get a copy of the practice test. They also had to become somewhat familiar with Basic notation to interpret these questions. They were not enthusiastic about this gimmick and it didn't make the students aware that the computer could be as useful as their calculators and more powerful. With this goal in mind I expanded my computer offerings and met with real success.

WHAT WAS DIFFERENT?

There were several changes in my subsequent computer assignments. The first difference was that only "interactional" programs were used. This was an important change. this work really involved computers instead of an automatic typewriter.

Secondly, while trying to preserve the "optional" nature of the computer work, I provided highly motivational grading structures to encourage it. Each completed computer assignment gained 5 extra credit points on the next 100 point exam. Calculus is a problem solving course, but story problems make exams very difficult. There were enough computer assignments in each unit to cover the total points in story problems on the next exam. The computer assignments were offerred as a grade cushion as well as a new problem solving tool.

Lastly, the assignments were varied enough to maintain interest, though most involved graphing and altogether only four different programs were used. The students were required to sign-on to a terminal, get & run programs, enter functions in BASIC notation and type in programs that were pre-written. The assignments were very curriculum oriented.

I hadn't originally planned a complete program but the first assignments were so successful that the students asked me for more. I am including all the assignments I have used. I have several more planned for next semester.

GETTING STARTED

The first no-credit computer assignment involved signing-on and running a quiz program. The computer asked questions and the student typed in an answer which the computer scored. The program randomly chose numbers so that it could be rerun indefinately i.e. corresponding to a request for the slope of the line through 2 points, different points appeared each run. The motivation for running this program was an actual in-class graded quiz generated by the same program. This program was a good ice-breaker. The hardest part seems to be signing on the first time and the reward must be big enough to minimize this obstacle.

KEEPING THE BALL ROLLING

Students were encouraged to bring their work to class before due dates. Problems were ironed out as well as excellent results displayed. What seemed to cause the project to pick up steam and gather users rather than lose them was that some students started bragging about how easy it really was. The students helped and encouraged one another to give it a try. Reluctant learners came back with smiles and results. I also chose a few excellent papers and posted them in a hallway display case.

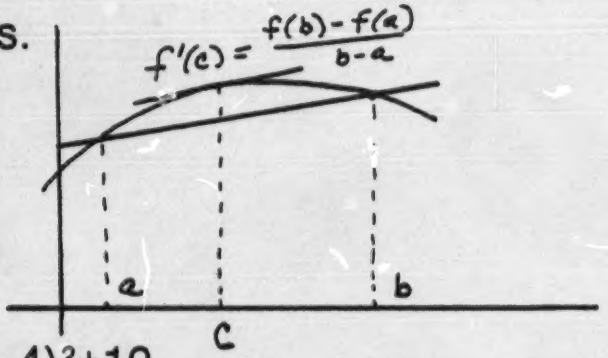
SUCCESSFUL OUTCOME

While my goal was limited to exposing students to computers, the results exceeded my expectations. The assignments were so heavily intertwined with calculus topics that the students were gaining insights into mathematics through the activities. There were even opportunities for me to gain insights into the use of the computer. I stopped myself while explaining that finding the value of non-rational real roots of polynomials would be a technique learned in a later course, (thinking of course of Newton's method) when I realized that with a simple computer graph of the function near the root we could get a 2 or 3 decimal approximation.

I don't know how many of my students took Calc II who weren't intending to but I do know that several of my students developed a taste for computers and enrolled in subsequent programming classes.

Computer Assignment 1
(Mean Value Theorem)

1. Make a computer illustration of the mean value theorem and label parts.



a) Graph $f(x) = -\frac{1}{2}(x-4)^2+10$
$a=2 \quad b=8$

b) Graph the secant line which connects
$(a,f(a))$ and $(b,f(b))$

c) Graph the tangent line to the curve at c where

$$f'(c) = \frac{f(b) - f(a)}{b - a}$$

(Asymptotes)
Computer Assignment 2

1. Graph: $f(x) = \frac{3x^2}{(x-2)(x+3)}$

2. Graph the asymptotes on the same axis or put in with dotted line if unable to get computer to graph.

3. USING YOUR PICTURE Find these answers.

$\lim_{x \to +\infty} f(x) =$ _____

$\lim_{x \to -\infty} f(x) =$ _____

$\lim_{x \to 2^-} f(x) =$ _____

$\lim_{x \to 2^+} f(x) =$ _____

Computer Assignment 3
(Absolute max and absolute min)

1. Signon as usual { 769-8810
   HEL—U111,PAR

2. Immediately type in the following lines (see back) Press RETURN after each line.

3. Type RUN , and FIND answer.

4. Now do the problem using calculus and compare answers.

   What are the dimensions of a rectangle with fixed perimeter 50 ft. and maximum area? (Answer. accurate to one decimal place.)

5. Which lines of the program would need to be changed to solve the same problem for perimeter = 100?

6. Which solution method is easier?
   Which generalizes best?

```
10    P=50
20    A=Ø
30    FOR L=Ø TO P/2 STEP .1
40    W=P/2-L
50    A1=L*W
60    IF A >=A1 THEN 100
70    A=A1
80    L1=L
90    W1=W
100   NEXT L
110   PRINT "THE MAXIMUM AREA IS" A
120   PRINT "THE LENGTH AND WIDTH WHICH"
130   PRINT "PRODUCE THIS AREA"
140   PRINT L1 MAX W1 "AND" L1 MIN W1
150   PRINT
160   END
```

Computer Assignment 4
(Higher Order Derivatives)

1. Graph

$$f(x) = \frac{(x+3)(x+2)(x+1)(x-1)(x-2)}{24}$$

(use -4 to 4 for your domain)

2. On the same axis graph: $f(x)$, $f'(x)$, $f''(x)$ and $f'''(x)$

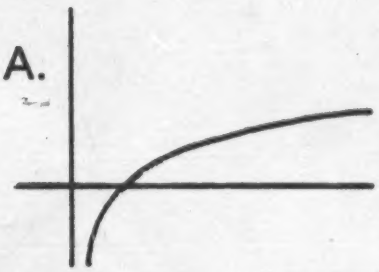
(Hint: if $f(x) = {}^1/_{24}h(x)$ then $f'(x) = {}^1/_{24}h'(x)$)

3. Use color coding to show which graph is which function or derivative and state the derivatives.

(Concavity and Points of Inflection)
Computer Assignment 5

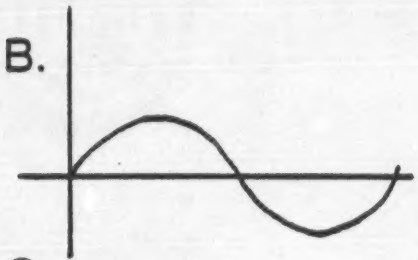
1. Sketch on the same set of axes the second derivative for each of these functions. Check your work using the computer to graph f(x) and f''(x). Note all pts. of inflection on the computer output by sketching in the inflectional tangent lines.

A.



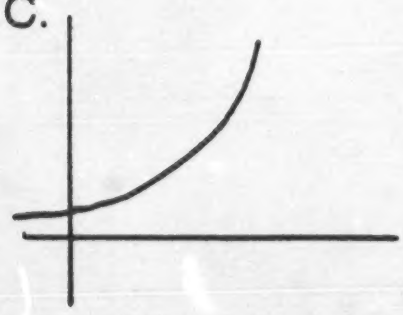
Log(x) or
f(x) = LN(x)
$f''(x) = -1/x^2$

B.



f(x) = sin(x)
f''(x) = -sin(x)

C.



f(x) = exp(x)
f''(x) = exp(x)

Computer Assignment 6
(Differential Equations)

1. Starting with $f''(x) = 2x+1$
   $f'(x) = 2$ when $x = 1$
   $f(x) = 1$ when $x = 1$

   Find $f(x)$, $f'(x)$ and $f''(x)$

2. Graph all 3 functions on the same axis to check if they are related properly.

   ie. $f'(x)$ is above x axis when
   $f(x)$ is increasing.

   $f''(x)$ is above x axis when
   $f(x)$ is concave upward.
   etc.

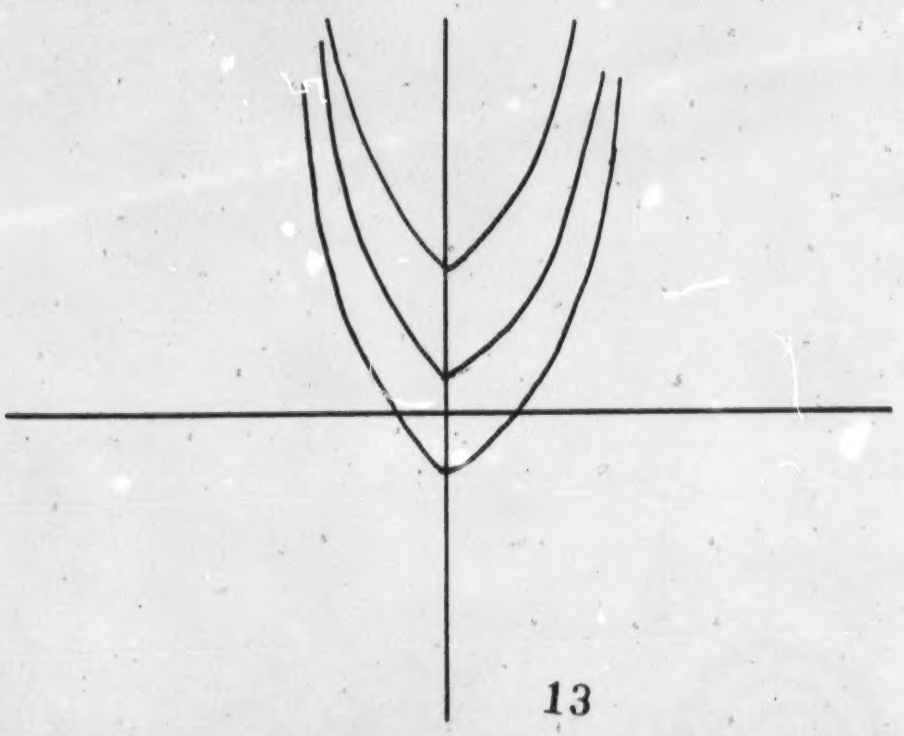
Computer Assignment 7
(Family of curves)

1. Find the general solution to this differential equation

   $dy/dx = 3x+4$

2. Graph this FAMILY of curves (letting C have at least 3 different values) on the same axis.

3. Identify each curve on the axis.



Computer Assignment 8
(Outer & Inner Area)

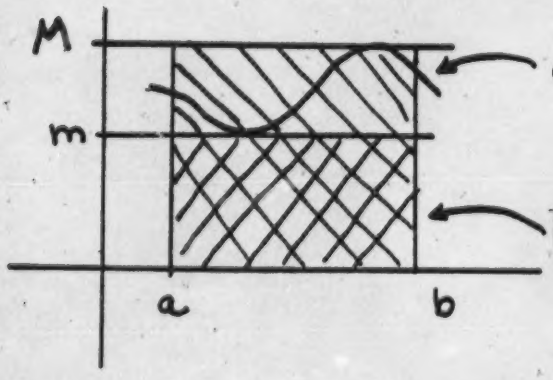
1. Find the smallest and largest possible values for

$$\int_3^4 (x^4-8x^2+16)dx$$

2. Using the computer, Graph:

   y = M maximum value of function
   y = m minimum value of function
   y = f(x)
   on the same axis.

3. Draw in x = 3 and x = 4.
   and shade areas of rectangles



outer area = upper limit of integral

inner area = lower limit of integral

Computer Assignment 9
(Mean Value Theorem For Integrals)

1. Graph this function $f(x) = x^3-6x^2+9x+1$ (using computer)

2. Find $f(X)$, $f(X)(b-a) = \int_a^b f(x)$ where $f(x) = x^3-6x^2+9x+1$ on $(\frac{1}{2}, 4)$

3. Graph $y = f(X)$ on same axis as $f(x)$

4. Draw in $x = a$ and $x = b$

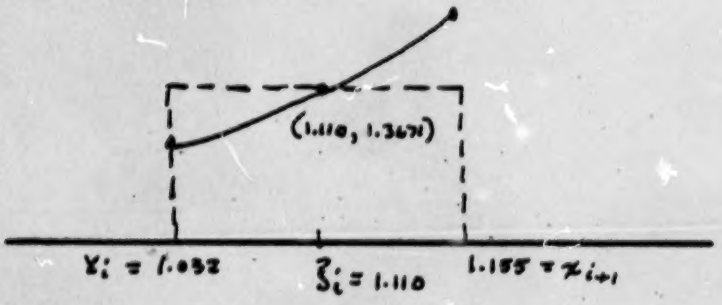
5. Compare area of rectangle with that under curve.
   Shade area above $f(X)$ and below $f(x)$ one color and area below $f(X)$ and above $f(x)$ another. The two areas should be equal?

6. Locate X on axis between a and b

Computer Assignment 10
(Reimann Sum)

1. Here (see back) is an example of a run of *CALN. for $\int_0^2 x^3 dx$

   From this run I know that the interval between 1.032 and 1.155 was aproximated with a rectangle of height $(1.110)^3$ and width .123 so that area = .4942



2. GET-*CALN
   100 DEF FNF(x)=x^2 find $\int_0^4 x^2 dx$
   RUN
   use limits of 0,4
   use norm of 1.5

3 Using your results make a sketch indicating partition points, ξ_i points & rectangle

HEL-U111,PAR

$\int_0^2 x^3 = ?$

W.I.T.S. Thu Dec 4, 1980 11:18 AM PORT #14

GET-*CALN
100 DEF FNF(X)=X^3 ← enter the function
RUN
CALN

← enter a and b

PLEASE GIVE ME THE LIMITS OF THE INTERVAL?0.0,2
FOR LIMITS [0 , 2]
FOR THE RIEMANN SUM YOU MUST SET THE SIZE OF THE NORM
NORM SIZE IS?.5 ← any smaller & you could wait for hours.

```
POINT #   3    IS   +0.123   ;FITS BETWEEN   +0.000  AND   +2.000
     NORM=  1.87683   FOR (  +0.123,  +2.000)
POINT #   4    IS   +1.471   ;FITS BETWEEN   +0.123  AND   +2.000
     NORM=  1.34794   FOR (  +0.123,  +1.471)
POINT #   5    IS   +0.457   ;FITS BETWEEN   +0.123  AND   +1.471
     NORM=  1.01397   FOR (  +0.457,  +1.471)
POINT #   6    IS   +1.324   ;FITS BETWEEN   +0.457  AND   +1.471
     NORM=  0.86684   FOR (  +0.457,  +1.324)
POINT #   7    IS   +0.543   ;FITS BETWEEN   +0.457  AND   +1.324
     NORM=  0.76055   FOR (  +0.543,  +1.324)
POINT #   8    IS   +1.155   ;FITS BETWEEN   +0.543  AND   +1.324
     NORM=  0.61117   FOR (  +0.543,  +1.155)
POINT #   9    IS   +1.485   ;FITS BETWEEN   +1.471  AND   +2.000
     NORM=  0.61117   FOR (  +0.543,  +1.155)
POINT #  10    IS   +1.032   ;FITS BETWEEN   +0.543  AND   +1.155
     NORM=  0.51481   FOR (  +1.485,  +2.000)
POINT #  11    IS   +0.225   ;FITS BETWEEN   +0.123  AND   +0.457
     NORM=  0.51481   FOR (  +1.485,  +2.000)
POINT #  12    IS   +0.913   ;FITS BETWEEN   +0.543  AND   +1.032
     NORM=  0.51481   FOR (  +1.485,  +2.000)
POINT #  13    IS   +0.275   ;FITS BETWEEN   +0.225  AND   +0.457
     NORM=  0.51481   FOR (  +1.485,  +2.000)
POINT #  14    IS   +1.349   ;FITS BETWEEN   +1.324  AND   +1.471
     NORM=  0.51481   FOR (  +1.485,  +2.000)
POINT #  15    IS   +0.560   ;FITS BETWEEN   +0.543  AND   +0.913
     NORM=  0.51481   FOR (  +1.485,  +2.000)
POINT #  16    IS   +1.496   ;FITS BETWEEN   +1.485  AND   +2.000
     NORM=  0.50375   FOR (  +1.496,  +2.000)
POINT #  17    IS   +1.832   ;FITS BETWEEN   +1.496  AND   +2.000
   1   +0.060+(  +0.000,  +0.123) f(x)=   +0.0002  AREA=   +0.0000
   2   +0.187+(  +0.123,  +0.225) f(x)=   +0.0065  AREA=   +0.0007
   3   +0.273+(  +0.225,  +0.275) f(x)=   +0.0203  AREA=   +0.0017
   4   +0.322+(  +0.275,  +0.457) f(x)=   +0.0334  AREA=   +0.0078
   5   +0.475+(  +0.457,  +0.543) f(x)=   +0.1070  AREA=   +0.0170
   6   +0.553+(  +0.543,  +0.560) f(x)=   +0.1693  AREA=   +0.0199
   7   +0.827+(  +0.560,  +0.913) f(x)=   +0.5649  AREA=   +0.2190
   8   +0.967+(  +0.913,  +1.032) f(x)=   +0.9047  AREA=   +0.3271
   9   +1.110+(  +1.032,  +1.155) f(x)=   +1.3671  AREA=   +0.4942
  10   +1.194+(  +1.155,  +1.324) f(x)=   +1.7028  AREA=   +0.7626
  11   +1.346+(  +1.324,  +1.349) f(x)=   +2.4391  AREA=   +0.8442
  12   +1.357+(  +1.349,  +1.471) f(x)=   +2.4991  AREA=   +1.1468
  13   +1.475+(  +1.471,  +1.485) f(x)=   +3.2075  AREA=   +1.1940
  14   +1.495+(  +1.485,  +1.496) f(x)=   +3.3429  AREA=   +1.2309
  15   +1.811+(  +1.496,  +1.832) f(x)=   +5.9426  AREA=   +3.2271
  16   +1.861+(  +1.832,  +2.000) f(x)=   +6.4481  AREA=   +4.3094
TOTAL AREA= 4.3094
 PLEASE GIVE ME THE LIMITS OF THE INTERVAL?
```